7A STRUCTURAL ORGANISATION IN ANIMALS —MORPHOLOGY AND ANATOMY OF ANIMALS

Morphology (Gr. *morphe* = form; *logos* = study) is the study of the external features of an organism without dissecting it. **Anatomy** (Gr. *ana* = up, *tome* = to cut) deals with the internal structure of an organism as revealed by dissection.

Morphology, anatomy and functions of different systems of earthworm (annelid), cockroach (insect) and frog (amphibian) are described in this chapter. Systematic position, habitat, habits and interaction with mankind are also mentioned to create interest about these animals.

PHERETIMA (Earthworm)*

Earthworms are cosmopolitan in distribution, except the arctic and antarctic zones. As many as thirteen species of *Pheretima* live in the Indian soil. *Pheretima posthuma* is very common in Northern India. *Megascolex* is the common earthworm of South India. The *Pheretima posthuma* was thoroughly described in a memoir (1926) by Dr. K.N. Bahl of Lucknow University. **Lumbricus** is European earthworm.

Systematic Position :

Phylum	—	Annelida
Class	—	Oligochaeta
Order	—	Terricolae
Family	—	Megascolicidae
Genus	—	*Pheretima*
Species	—	*posthuma*
Common Name	—	Earthworm

Habitat. Earthworms are found in wet soil containing rich organic matter. The latter is its main food while wet soil helps in gaseous exchange. They usually live in the upper layer of the soil, but when the environmental conditions are not favourable, such as too much hot, dry climate, earthworms burrow up to 10 feet deep. During rainy season, they come out and can be seen easily in lawns, fields and gardens. Life of earthworm is 3.5 to 10.5 years.

Habits. These **nocturnal** worms have the following habits.

Feeding. Earthworms mainly feed upon the decaying orgnaic matter found in the soil. They also feed on the bits of plants and animal matter. Thus type of feeding in earthworms is **detritus**. During feeding, the buccal cavity is everted, and soon after the food alongwith soil is drawn into the mouth by sucking action of the pharynx. The muscles extending from the pharynx to the body wall control this action. The food is digested in the gut and undigested food matter along with the soil is passed out through the anus in the form of little heaps of pellets, known as "**worm castings**".

Burrowing. Earthworms dig their burrows by inserting their anterior pointed end into small

*For Competitive Exams.

carbon dioxide, water and energy. Carbon dioxide from the tissues diffuses outside into the surrounding atmosphere.

Breeding. The earthworm breeds in rainy season. It is **hermaphrodite** or **bisexual** or **monoecious**, *viz.* both male and female sex organs are found in one individual. Earthworms are **protandrous**, *viz.* male sex organs mature earlier than the female. Thus self fertilization is not possible and, therefore, cross fertilization occurs. This involves copulation of two worms and mutual exchange of spermatozoa (sperms). The animal is **oviparous**. Several eggs and spermatozoa are packed in the **cocoon** and on an average four baby worms develop in one cocoon.

Regeneration. It is the regrowth of the body part, which has been lost or injured. Earthworms possess a great power of regeneration. It is observed that if a worm is cut into two parts accidentally, the anterior half will develop the posterior half, the anterior part can be formed only if 4 to 6 anterior segments are removed. **Grafting** is also possible in the earthworms. A cut part of an earthworm can be grafted to another worm.

Morphology or External Characters

Shape, Size and Colour. An elongated bilaterally symmetrical body is pointed in front and blunt behind. The dorsal surface is recognised by a *dark median line, which is in fact a dorsal blood vessel beneath the skin*. The ventral surface can be recognised by the presence of genital apertures and papillae. The size of the earthworm varies. The mature *P. posthuma* is about 150 mm. in length and 3 to 5 mm. in width. The colour is glistening dark brown due to the pigment **porphyriu**. The dorsal surface is darker than ventral.

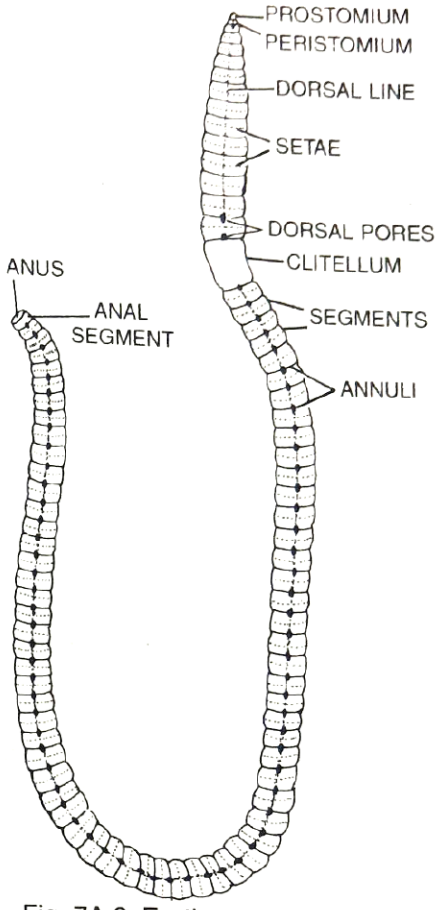

Fig. 7A.2. Earthworm in dorsal view.

Segmentation. The elongated body comprises 100 to 120 segments or **metameres** which are distinct externally by the circular burrows, the **annuli**. The latter correspond internally as **septa** to divide the body cavity into compartments. This type of segmentation which is both external and internal, is known as true or **metameric segmentation** or **metamerism**. The earthworms do not possess a distinct head nor any specialized sense organs, like eyes. The first segment of the body is termed as **peristomium** which bears a fleshy lobe, the **prostomium**, anteriorly. The peristomium contains a crescentic mouth, overhung by the prostomium the latter is sensory in function. The

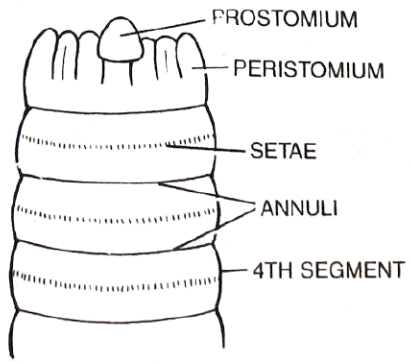

Fig. 7A.3. Magnified view of the anterior end of earthworm.

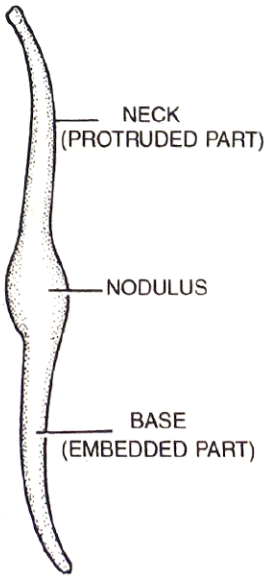

Fig. 7A.4. Seta of earthworm.

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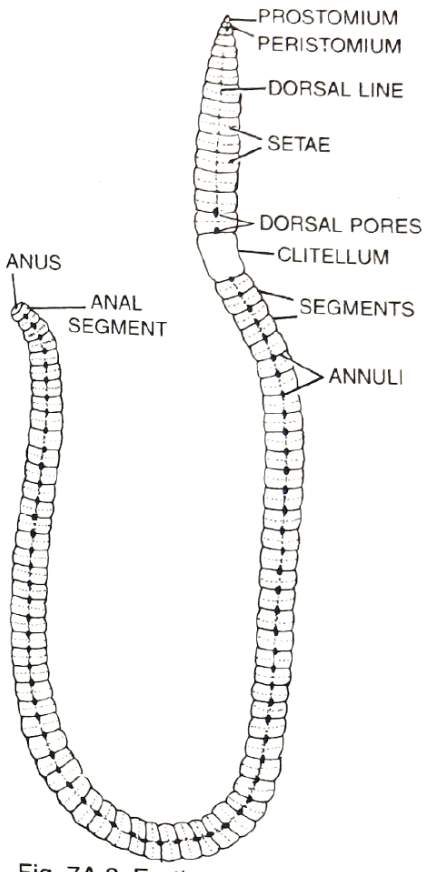

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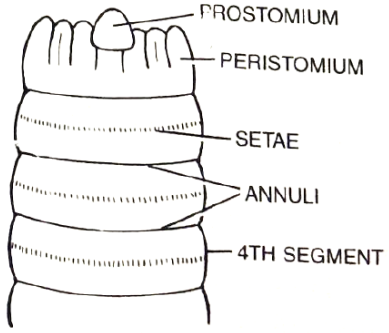

Fig. 7A.3. Magnified view of the anterior end of earthworm.

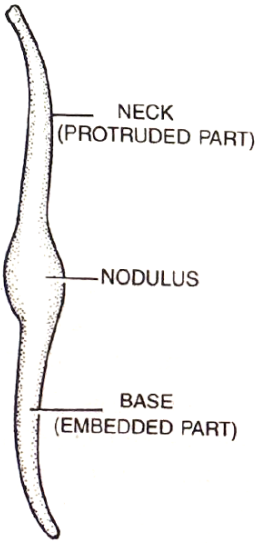

Fig. 7A.4. Seta of earthworm.

clitellum (= cingulum), a prominent circular band of glandular nature, is found from the 14th to 16th segments. These segments are not distinct externally. The clitellum secretes mucus and albumen. Its secretion helps in the formation of cocoon, which is used for fertilization of the eggs. On the basis of the clitellum, the body of earthworm is divisible into **preclitellar, clitellar** and **post-clitellar regions.**

Differences between Prostomium and Peristomium

Prostomium	*Peristomium*
1. It is a fleshy lobe which projects from peristomium.	1. It is the first segment.
2. It does not contain mouth.	2. It contains mouth.
3. It serves as wedge to force open cracks in the soil into which the earthworm lives.	3. It does not happen in peristomium.
4. It is sensory in function.	4. It is not sensory.

Setae. *Except the first, the last and clitellar segments* each segment bears a ring of tiny curved, chitinous structures known as **setae** or **chaetae**. They are embedded in the skin. Each seta (singular of setae) lies in a **setal sac**, which is a small pit in the skin. The sac has special muscles to move the seta out or in and to bend it forward or backward. The seta is somewhat 'S' shaped having a swollen middle portion, the **nodulus**. The part of seta in the setal sac is called the **base** and that projecting out is termed the **neck**. The setae are renewed if lost. When setae are arranged in a ring in each segment such arrangement of setae is called **perichaetine** arrangement. It is found in *Pheretima*. When setae are arranged in two pairs on each side in each segment, such arrangement is called **lumbricine**. It is present in *Lumbricus* . The setae hold the substratum firmly. Thus, they help in the locomotion. They also keep the two copulating worms together by penetration into each other's body.

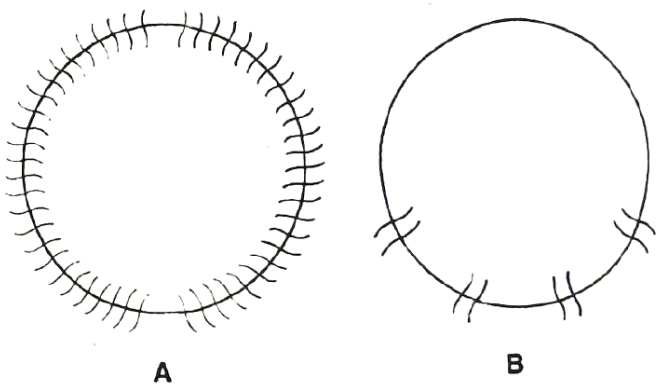

Fig.7A.5. Arrangement of setae. A, Perichaetine. B, Lumbricine.

Pores and Apertures. Following pores/apertures are found on the body surface of the earthworm.

(i) **Mouth**. The peristomium encloses a crescentic shaped mouth on its anterior end. It is overhung by the fleshy prostomium. The mouth is used in the feeding.

(ii) **Anus**. It is a vertical slit like terminal opening, situated in the last or **anal segment** or **pygidium**. It passes out the indigestible food matter.

(iii) **Female Genital Pore**. It is a single opening, situated on the ventral side of the 14th segment. The ova are passed out by this pore.

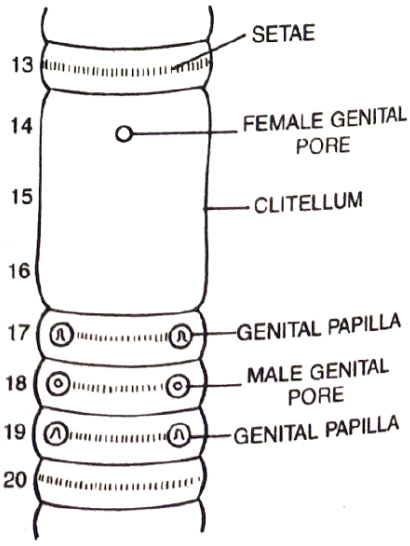

Fig. 7A.6. Genital portion of earthworm in ventral view.

(iv) **Male Genital Pores**. These are a pair of crescentic openings, lying on the ventral side of the 18th segment. Male reproductive fluid containing sperms is discharged by these pores.

(v) **Apertures of Accessory Glands.** There are present two pairs of **genital papillae** on the ventral side of the 17th and 19th segments, one pair in each segment. Each papilla has fine apertures of accessory glands.

(vi) **Spermathecal Pores**. These are four pairs of small openings situated ventro-laterally in the intersegmental grooves of the segments 5/6, 6/7, 7/8, and 8/9 on each side. Each opening leads into a spermatheca, in which the sperms of the other earthworm are stored.

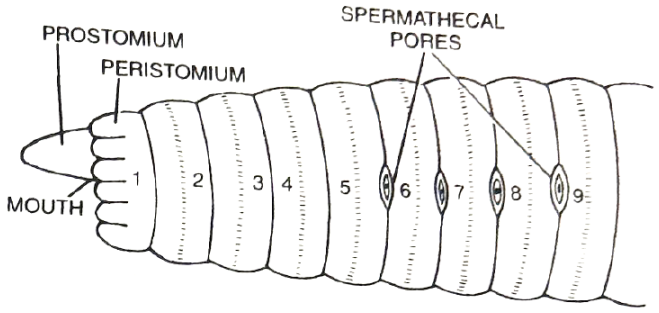

Fig. 7A.7. Lateral view of the anterior portion of earthworm.

(vii) **Nephridiopores**. These are numerous, minute openings, scattered irregularly all over the body surface, except the first two segments. The nephridiopores are the openings of the integumentary nephridia to expel out the nitrogenous wastes from the body.

(viii) **Dorsal pores**. These are minute openings, lying on the mid-dorsal line in the intersegmental grooves, behind the 12th segment. The first dorsal pore is situated in between 12th and 13th grooves. Other dorsal pores lie in each of the succeeding intersegmental grooves, except the last. The body cavity or coelom opens outside by these pores to discharge its coelomic fluid. The fluid keeps the body surface smooth and moist, and also protects the animal from the harmful bacteria.

Anatomy

Body wall.

It consists of the *cuticle, epidermis, muscular layer* and the *parietal* peritoneum.

1. **Cuticle**. It is a *thin delicate non-cellular* chitinous membrane which covers the entire body of the earthworm. It is secreted by the underlying epidermis.

2. **Epidermis.** It lies beneath the cuticle and consists of (i) **Supporting cells**, (ii) **Glandular cells**— (a) *Mucous* or *Goblet cells* (b) *Albumen cells* and *cocoon forming cells* (iii) **Basal cells** (iv) **Receptor cells** or **sensory cells** and (iv) **Setal cells** (seta forming cells).

3. **Muscular layer**. It lies inner to the epidermis. It consists of an outer layer of **circular muscles** and an inner layer of **longitudinal muscles**. A set of circular muscles also lies outer to parietal peritoneum. The longitudinal

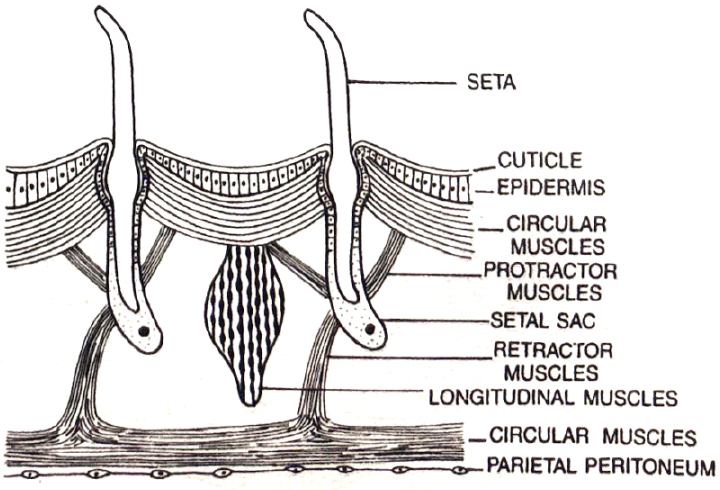

Fig. 7A.8. T.S. body wall through the setal sacs and muscles of the setae of earthworm.

muscles layer lies in long paralleled bundles. Two sets of muscles, the **protractor muscles** and **retractor muscles** are attached to the basal part of each setal sac. By the contraction of the protractor muscles the setae get protruded, while the contraction of retractor muscles makes the setae withdraw into the setal sac. Thus, the muscles are helpful in the locomotion of the earthworm.

4. **Parietal layer of Coelomic Peritoneum** or **Parietal Peritoneum**. It is the innermost layer of the body wall, lying next to the longitudinal muscles layer. It forms the outer boundary of coelom and is, therefore, called parietal peritoneum. It secretes coelomic fluid.

Functions of Body Wall :- (1) It maintains the characteristic shape of the body. (2) It protects the internal organs. (3) The cuticle prevents excessive evaporation. (4) It serves as an ideal respiratory organ. (5) The receptor cells play a vital sensory function. (6) The albumen helps in the formation of cocoon. It also serves as a food for the developing earthworm inside the cocoon. (7) Setae and muscles are responsible for locomotion. (8) Excretory matter is passed out through nephridiopores.

Coelom (Body Cavity).

Coelom is the space between the body wall and alimentary canal lined externally by the **parietal peritoneum** and internally by the **visceral peritoneum.** It is filled with the coelomic fluid. In earthworm coelom is formed by the splitting of the mesoderm of the embryo, therefore, it is called **schizocoelom**.

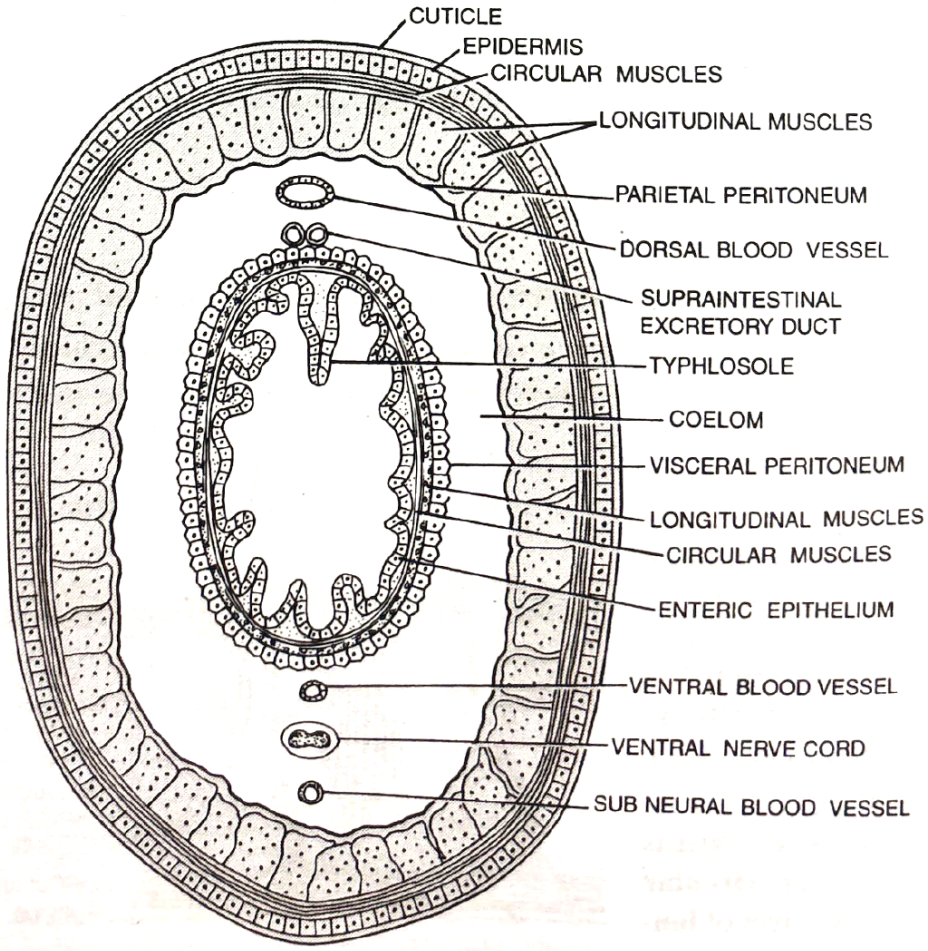

Fig. 7A.9. T.S. *Pheretima* through typhlosolar region of intestine.

Septa. The coelom in the earthworm is not a continuous cavity but is divided into compartments by transverse circular partitions, the **septa**. However, it may be stated here that the coelom of the first four segments is continuous or undivided. Thus the *first septum* which is thin and membranous lies between the fourth and fifth segments, the next five septa lying between segments 5/6, 6/7, 7/8, 8/9 or 9/10 and 10/11 are thick and muscular. One of the two septa, either between the 8th. and 9th or between the 9th and 10th segments is absent.

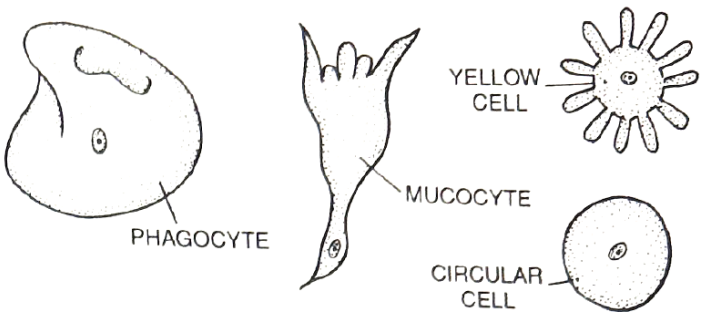

Fig. 7A.10. Corpuscles of coelomic fluid of earthworm

Coelomic Fluid. It is a milkish fluid filling the coelom. It consists of water, proteins, salts, etc. and is slightly alkaline in nature. It contains four types of corpuscles (Fig. 7A.10).

(i) **Phagocytes (= Eleocytes)**. They move like *Amoeba* and engulf harmful germs. (ii) **Circular cells**. The function of these cells is not fully understood. (iii) **Chloragogen cells or Yellow cells**. These cells are excretory in function. (iv) **Mucocytes**. These are elongated cells whose one end forms a fan like structure and the other narrow end contains the nucleus. The function of these cells is not known.

Functions of Coelomic Fluid : (1)The coelomic fluid oozes out through the dorsal pores where its phagocytes kill the harmful microorganisms. (2) It also keeps the skin moist and thus helps in respiration. (3) Some excretory matter is also got rid off through the coelomic fluid. (4) It makes the body segments turgid and thus helps in locomotion. (5) The coelomic fluid serves as **hydroskeleton**. (6) It keeps the internal organs moist.

Lymph glands. These are white fluffy bodies which are found arranged on either side of the dorsal blood vessel from 26th segment and extend to the successive segments. These glands are believed to produce the phagocytes of the coelomic fluid.

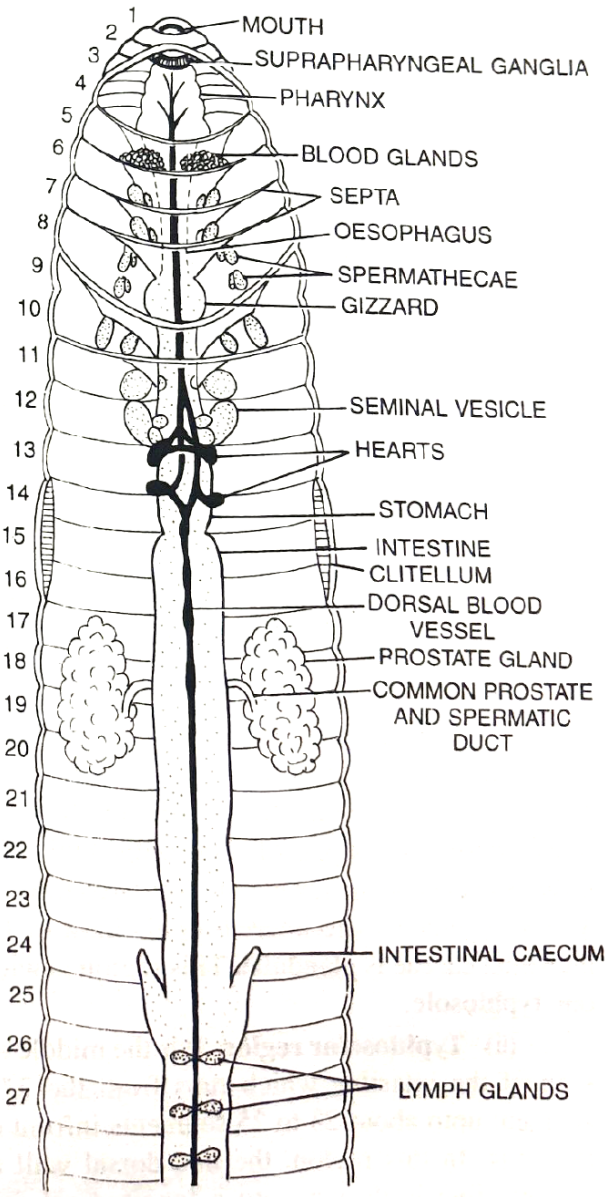

Fig. 7A.11. Anatomy of Earthworm.

Digestive System

It consists of alimentary canal (Fig. 7A.12) and digestive glands.

Alimentary canal. It is a straight tube like structure with variable diameter extending from the mouth to the anus. It consists of the buccal cavity, pharynx, oesophagus, gizzard, stomach and intestine.

1. **Mouth**. Mouth is situated in the first segment (peristomium). It is overhung dorsally by sensitive fleshy lobe the prostomium—an extension of the peristomium.

2. **Buccal Cavity**. Mouth leads into a thin walled *buccal cavity* which extends from first segment to the 3rd segment.

3. **Pharynx**. The buccal cavity is followed by the pharynx which extends upto the fourth segment. On the roof of the pharynx a muscular, glandular and vascular **pharyngeal gland** or **mass** is present.

4. **Oesophagus**. The pharynx leads into a narrow and tubular structure, the *oesophagus* which extends from the fifth segment to the seventh segment.

5. **Gizzard**. In the eighth segment or in the eighth and ninth segments in those earthworms in which septum between these two segments is absent the oesophagus is dilated into an oval strucutre, the *gizzard*. *Gizzard* grinds the food with the help of thick muscles and cuticle.

6. **Stomach**. Gizzard is followed by a tubular stomach which extends from the ninth to the fourteenth segment. The glandular cells of stomach secrete a proteolytic enzyme.

7. **Intestine**. The stomach leads into a wide thin walled intestine which runs from fifteenth segment to the last segment where it opens to the outside by means of anus. The intestine can be distinguished into three regions.

(i) **Pretyphlosolar region**. It is the anterior region of the intestine which extends from 15th to the 26th segment. In 26th segment, the intestine gives off a pair of short outgrowths, the **intestinal caecae** which extend forwards through 3 or 4 segments. The internal epithelium of the intestinal caecae is glandular. This region is without typhlosole.

(ii) **Typhlosolar region**. It is the middle region of the intestine which runs from the 27th segment upto about 23 to 25 segments infront of the anus. In this region, the mid-dorsal wall of the intestine is thrown into a longitudinal fold which is known as **typhlosole**. The typhlosole increases the absorptive surface of the intestine.

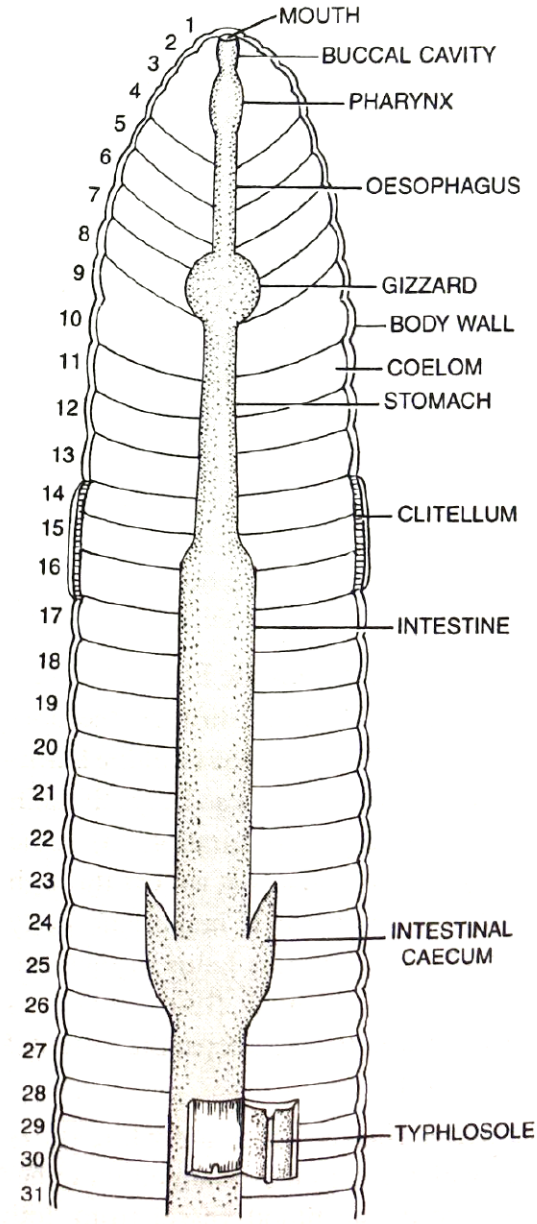

Fig. 7A.12. Alimentary canal of Earthworm.

(iii) **Post-typhlosolar region**. It is the posterior region of the intestine which lies in the last 23 to 25 segments. It mainly stores the faecal matter and opens to the exterior through the anus. This region is without typhlosole.

8. **Anus**. It is a slit like opening situated in the **anal (last) segment**, which opens to the outside to egest the faecal matter.

Digestive Glands. The following digestive glands are associated with the alimentary canal of the earthworm :

(i) **Pharyangeal gland** or **mass**. It is a muscular, glandular and vascular mass which is situated at the roof of the pharynx. Its glandular cells are known as **chromophil cells** which secrete a fluid, the **saliva** which is passed on to the lumen of the pharynx. Saliva contains *mucus* (a lubricating agent) and a proteolytic enzyme. (ii) **Gastric epithelium**. The glandular cells of the enteric epithelium of the stomach secrete a gastric fluid which contains proteolytic enzyme. (iii) **Intestinal epithelium**. The glandular cells of the enteric epithelium of the intestine secrete an intestinal fluid which contains proteolytic, amylolytic and lipolytic enzymes. (iv) **Intestinal caecae**. These are the two outgrowths of the intestine arising in the 26th segment and extend forwards upto 3 or 4 segments. They secrete a digestive fluid which contains amylolytic type of enzyme which is transferred to the lumen of the intestine.

Ingestion. Earthworms mainly feed upon the decaying organic matter found in the soil. They also sometimes feed on the bits of plant and animal matter. Thus earthworms are **omnivorous** in diet. During feeding, the buccal cavity is everted and soon after the food along with soil is drawn into the mouth and then into the pharynx by the sucking action of the pharynx. The muscles extending from the pharynx to the body wall control this action.

Digestion. In the pharynx, secretion of the pharyngeal gland cells (= chromophil cells) contains mucin and protein-splitting enzyme. The mucin lubricates the soil for easy passage onwards while enzyme splits the protein of food particles into peptones and proteoses. The soil and food particles are carried to the gizzard through the oesophagus. The soil and food particles are ground up in the gizzard. Glandular cells of stomach epithelium secrete another proteolytic enzyme which splits the remaining proteins of food into peptones and proteoses. Following enzymes are secreted by glandular cells of intestine and intestinal caecae which act in the intestine.

(i) **Proteases** complete the digestion of proteins by breaking the peptones and proteoses into amino acids. (ii) **Lipase** splits fats into fatty acids and glycerol. (iii) **Amylases** digest the starch and glycogen. (iv) **Cellulase** digests the cellulose of leaves, etc. (vi) **Chitinase** digests the chitin of insects. Thus digestion is completed in the intestine.

Absorption. Absorption of digested nutrients occurs in the intestine, especially in its typhlosolar region. Absorbed nutrients reach the blood capillaries of the intestinal wall and circulate throughout the body.

Egestion. The undigested food matter along with soil is passed out through anus in the form of little heaps or pellets, called the "worm castings".

Blood Vascular System

Blood vascular system of earthworm is **closed type** as the blood flows in the closed blood vessels.

Blood. It is a mobile connective tissue composed of blood plasma and blood corpuscles. A coloured respiratory pigment, the **haemoglobin**, is present in the plasma. Due to the presence of haemoglobin the colour of the plasma is red. Only one type of blood corpuscles, the **leucocytes**

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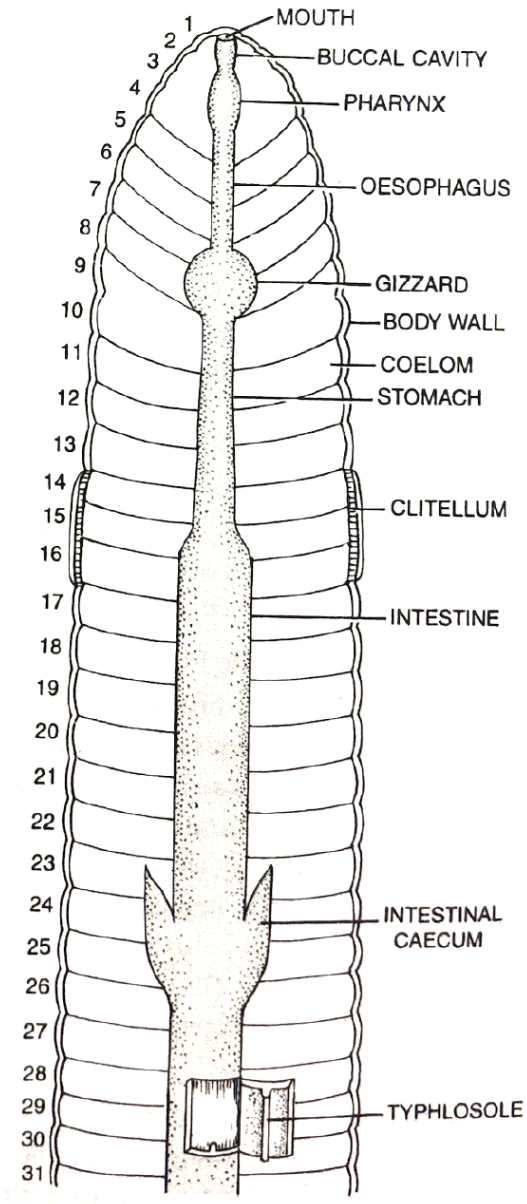

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(iii) **Post-typhlosolar region**. It is the posterior region of the intestine which lies in the last 23 to 25 segments. It mainly stores the faecal matter and opens to the exterior through the anus. This region is without typhlosole.

8. **Anus**. It is a slit like opening situated in the **anal (last) segment**, which opens to the outside to egest the faecal matter.

Digestive Glands. The following digestive glands are associated with the alimentary canal of the earthworm :

(i) **Pharyangeal gland** or **mass**. It is a muscular, glandular and vascular mass which is situated at the roof of the pharynx. Its glandular cells are known as **chromophil cells** which secrete a fluid, the **saliva** which is passed on to the lumen of the pharynx. Saliva contains *mucus* (a lubricating agent) and a proteolytic enzyme. (ii) **Gastric epithelium**. The glandular cells of the enteric epithelium of the stomach secrete a gastric fluid which contains proteolytic enzyme. (iii) **Intestinal epithelium**. The glandular cells of the enteric epithelium of the intestine secrete an intestinal fluid which contains proteolytic, amylolytic and lipolytic enzymes. (iv) **Intestinal caecae**. These are the two outgrowths of the intestine arising in the 26th segment and extend forwards upto 3 or 4 segments. They secrete a digestive fluid which contains amylolytic type of enzyme which is transferred to the lumen of the intestine.

Ingestion. Earthworms mainly feed upon the decaying organic matter found in the soil. They also sometimes feed on the bits of plant and animal matter. Thus earthworms are **omnivorous** in diet. During feeding, the buccal cavity is everted and soon after the food along with soil is drawn into the mouth and then into the pharynx by the sucking action of the pharynx. The muscles extending from the pharynx to the body wall control this action.

Digestion. In the pharynx, secretion of the pharyngeal gland cells (= chromophil cells) contains mucin and protein-splitting enzyme. The mucin lubricates the soil for easy passage onwards while enzyme splits the protein of food particles into peptones and proteoses. The soil and food particles are carried to the gizzard through the oesophagus. The soil and food particles are ground up in the gizzard. Glandular cells of stomach epithelium secrete another proteolytic enzyme which splits the remaining proteins of food into peptones and proteoses. Following enzymes are secreted by glandular cells of intestine and intestinal caecae which act in the intestine.

(i) **Proteases** complete the digestion of proteins by breaking the peptones and proteoses into amino acids. (ii) **Lipase** splits fats into fatty acids and glycerol. (iii) **Amylases** digest the starch and glycogen. (iv) **Cellulase** digests the cellulose of leaves, etc. (vi) **Chitinase** digests the chitin of insects. Thus digestion is completed in the intestine.

Absorption. Absorption of digested nutrients occurs in the intestine, especially in its typhlosolar region. Absorbed nutrients reach the blood capillaries of the intestinal wall and circulate throughout the body.

Egestion. The undigested food matter along with soil is passed out through anus in the form of little heaps or pellets, called the "worm castings".

Blood Vascular System

Blood vascular system of earthworm is **closed type** as the blood flows in the closed blood vessels.

Blood. It is a mobile connective tissue composed of blood plasma and blood corpuscles. A coloured respiratory pigment, the **haemoglobin**, is present in the plasma. Due to the presence of haemoglobin the colour of the plasma is red. Only one type of blood corpuscles, the **leucocytes**

are present in the blood of earthworm. The leucocytes kill the harmful germs which may enter the body of the earthworm.

Blood Vessels. Following are the prominent blood vessels found in earthworm.

1. **Dorsal blood vessel.** It extends from one end of the body to the other. The blood flows in this vessel from behind to forward on the dorsal side of alimentary canal. The dorsal blood vessel has valves which prevent the backward flow of blood. The dorsal blood vessel receives **dorso-intestinal vessels** from the intestine and stomach (14th segment only). It also receives **commissural vessels** from the subneural vessels. The dorso-intestinal vessels collect blood from the gut through **transverse vessels** that surround the gut.

2. **Ventral blood vessel.** It also extends from the one end to the other end of the body. It does not have any valves and flow of the blood is from the anterior to the posterior end of the body. It is a main distributing blood vessel. It gives off the **ventro-tegumentary vessels** which distribute blood to the body wall and the integumentary nephridia. A **septo-nephridial** branch given off from each ventro-tegumentary supplies blood to the septum and septal nephridia. Behind the 13th segment it gives off the **ventro-intestinal vessels** which supply blood to the intestine.

3. **Sub-neural blood vessel.** It runs from the posterior end of the body upto the fourteenth segment infront. It collects blood from the body wall through the **neurotegumentaries**. It also collects blood from the nerve cord through small blood vessels. The blood thus collected is sent to the dorsal blood vessel through commissural vessels. Each commissural vessel gives off a **septo-intestinal vessel** to supply blood to the intestine.

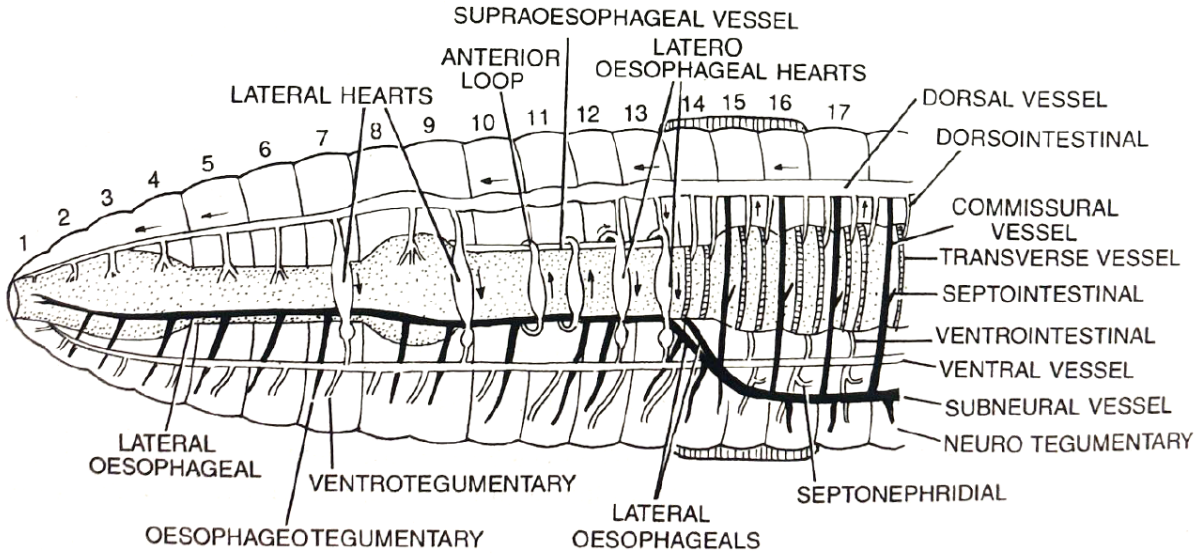

Fig. 7A.13. Circulatory system of earthworm in lateral view.

4. **Lateral oesophageal blood vessels.** (According to some authors, the part of alimentary canal from 5th segment upto the 14th segment is called oesophagus). It is a pair of blood vessels lying one on either ventrolateral side of alimentary canal between the body wall and the alimentary canal in the first fourteen segments. Both the lateral oesophageal vessels are continuation of the sub-neural vessel in the 14th segment. The lateral oesophageal vessels collect blood from the buccal cavity, pharynx, oesophagus and the body wall through **oesophageo-tegumentaries** and

carry this blood to the supraoesophageal vessel by two pairs of anterior loops situated in the 10th and the 11th segments.

5. **Supra-oesophageal blood vessel**. It is a single vessel which lies on the dorsal side of alimentary canal between the 9th and the 13 segments. It receives blood from the lateral oesophageals through two pairs of anterior loops and pour into two pairs of **latero-oesophageal hearts** present in the 12th and the 13th segments.

Hearts and anterior loops. In earthworm, there are present four pairs of tubular hearts. These hearts are provided with valves. The anterior two pairs of hearts, known as **lateral hearts** lie in the 7th and 9th segments and connect the dorsal blood vessel with the ventral blood vessel. They receive blood from the dorsal blood vessel and convey it to the ventral blood vessel. The posterior two pairs of hearts are called **latero-oesophageal hearts** and are situated in the 12th and 13th segments. The latero-oesophageal hearts apart from connecting the dorsal and ventral blood vessels are also joined with the supra oesophageal blood vessel. Latero-oesophageal hearts carry blood from the dorsal vessel and the supra oesophageal vessel to the ventral blood vessel.

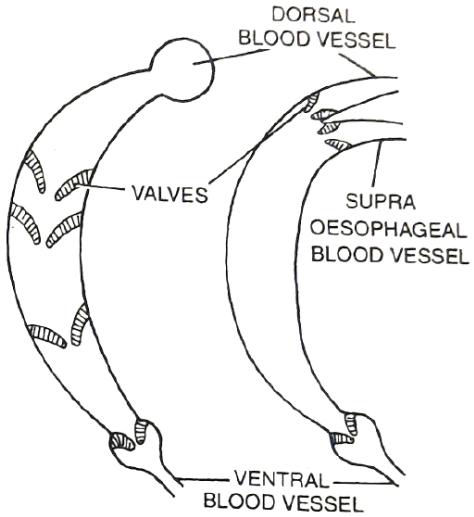

Fig. 7A.14. Hearts of earthworm : Left – Lateral heart, Right – Latero-oesophageal heart.

There are present two pairs of loop like vessels, the **anterior loops** in the 10th and 11th segments. These vessels connect the supra-oesophageal vessel to the lateral-oesophageal vessels. They have no valves. They carry blood from the lateral oesophageal vessels to the supra oesophageal vessel.

Blood glands. These are spherical masses situated in the 4th, 5th and 6th segments above the pharyngeal gland.(Fig 7A.11) They are considered to produce blood corpuscles and haemoglobin.

The special respiratory organs are lacking in earthworm. The gaseous exchange takes place through the body wall (skin) hence it is called **cutaneous respiration.**

Excretory System

The organs that help in the excretion constitute the excretory system. Excretion is a process through which excretory matter is eliminated from the body of the animal. Earthworms are both **ammonotelic** and **ureotelic**.The main excretory organs in earthworm are **nephridia** (sing. nephridium) which perform the function of excretion and osmoregulation. They are coiled tubular and microscopic structures. The nephridia occur in all the segments of earthworm except in the first two segments. Three types of nephridia are found in the earthworm according to their location, namely the *septal nephridia, pharyngeal nephridia* and *integumentary nephridia*. Nephridia are ectodermal in origin.

1. **Septal nephridia**. They are present attached to the septa behind the *fifteenth* segment. Each septum bears about 40–50 septal nephridia attached to its anterior and posterior surfaces. Thus there are 80 to 100 septal nephridia in each segment. **Nephrostome** collects excretory matter from the coelomic fluid of the coelom and the blood. Excretory matter passes through remaining parts of the nephridia and reaches the **terminal ducts**. The latter open into a pair of **septal excretory canals**. The canals carry excretory matter to a pair of **supra-intestinal excretory ducts**. These ducts pour the excretory material into the intestine in each segment through narrow **ductules**.

Since the septal nephridia discharge their excretory matter into the lumen of the alimentary canal/ enteron, they are called **enteronephric nephridia**. The opening of the nephridia into the alimentary canal is an adaptation for the conservation of water which is absorbed by the internal epithelial lining of intestine.

2. **Pharyngeal nephridia**. They occur in three pairs of bunches in the 4th, 5th, and 6th, segments lying on each side of the alimentary canal in these segments. Each bunch consists of a large number of nephridia. There are three pairs of ducts which run forwards. The ducts of the nephridia of the sixth segment open into the buccal cavity while the ducts from the nephridial bunches of the fourth and fifth segments open into the pharynx. These ducts carry excretory matter from the pharyngeal nephridia into the gut (buccal cavity/pharynx). Thus like septal nephridia, the pharyngeal nephridia are also **enteronephric nephridia**. Enteronephric condition is an adaptation for the conservation of water which is absorbed by the inner lining of the alimentary canal.

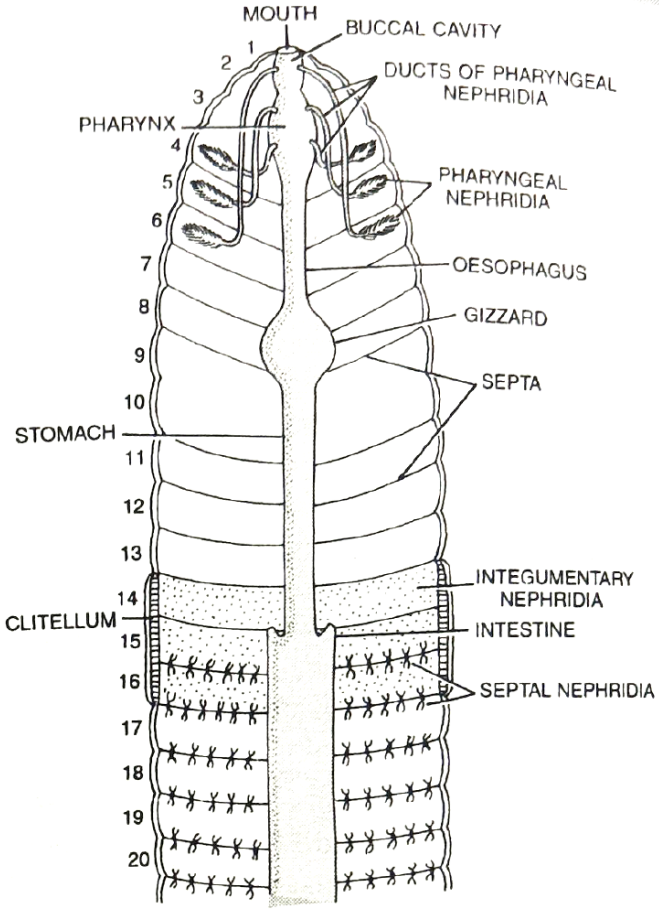

Fig A. 7A.15. General plan of distribution of nephridia in earthworm.

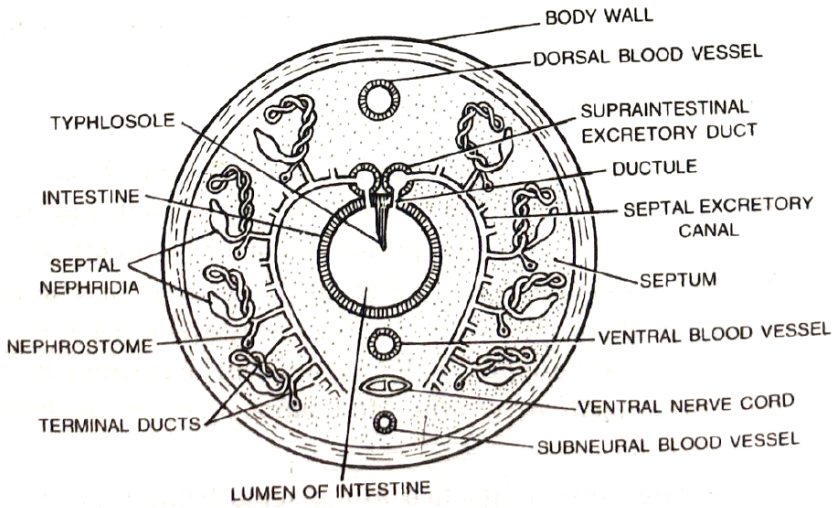

Fig.B. 7A.15 Arrangement of septal nephridia

3. **Integumentary nephridia.** They are found scattered in the body wall (integument) in each segment except the first two segments. In each segment they number from 200 to 250 except in the fourteenth, fifteenth and sixteenth segments (clitellar region) where their number is about ten times more than that in the other segments. Thus clitellar segments are often

called as the "forest of nephridia". They are the smallest of the three types of nephridia. These nephridia discharge their contents directly to the outside hence they are called **ectonephric (=exonephric) nephridia**. Thus they help the earthworm in keeping the skin moist for cutaneous respiration.

Chloragogen cells (yellow cells, Fig. 7A.10). These cells are excretory in function. The chloragogen cells take up excretory matter from the blood capillaries of the gut and from the coelomic fluid of the coelom. When these cells are filled with excretory mattter, they are either taken by the septal nephridia or pass directly to the outside on the surface of the skin through the dorsal pores. They also store glycogen and fat. Thus these cells are **analogous** to the liver of vertebrates.

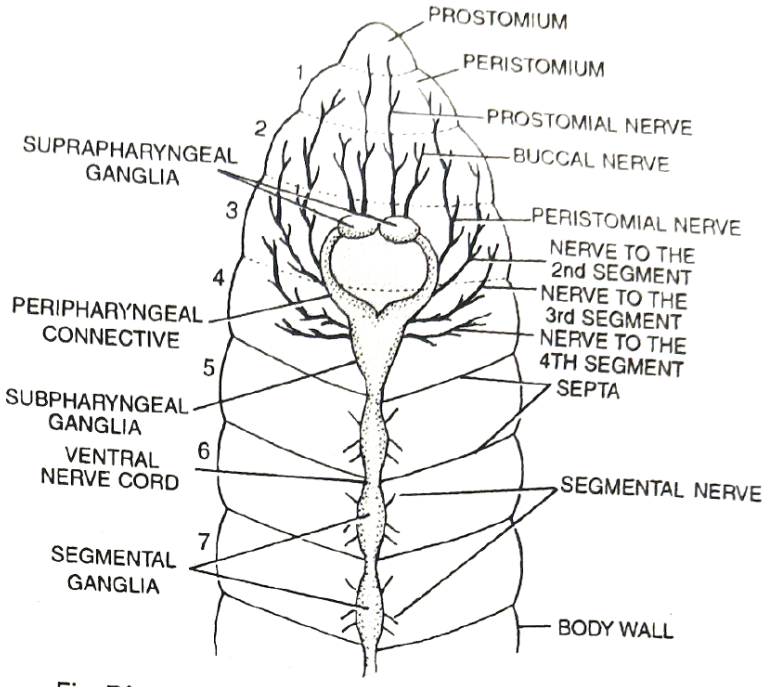

Fig. 7A.16. Nervous system of earthworm in dorsal view.

Differences between three types of Nephridia

Septal Nephridia	*Pharyngeal Nephridia*	*Integumentary Nephridia*
1. Occur in segment 15 onward.	Occur in segments 4, 5 and 6.	Occur in all segments except first two segments.
2. Attached to the septa.	Lie on the sides of the gut.	Attached to the body wall.
3. Vary from 80 to 100 per segment.	Lie in 3 paired groups.	Vary from 200 to 250 per segment. Clitellar segments have 2000–2500 each.
4. Open internally, having nephrostome.	Closed internally, without nephrostome.	Closed internally, without nephrostome.
5. Largest in size.	As large as septal nephridia.	Smallest in size (about half the size of septal nephridia).
6. Enteronephric.	Enteronephric.	Ectonephric.
7. Remove metabolic wastes from the blood and coelomic fluid.	Remove metabolic wastes from the blood only.	Remove metabolic wastes from the blood only.

Nervous System

A group of organs which controls and coordinates the various activities and movements of body parts is known as *nervous system*. The latter is not very well developed in earthworm. It is divided into *central nervous system, peripheral nervous system* and *autonomic nervous system.*

1. **Central nervous system.** It passes through the centre of the body and consists of a pair of **supra-pharyngeal (cerebral) ganglia**, a pair of **peripharyngeal connectives**, a pair of **sub-pharyngeal ganglia** and a **ventral nerve cord**. The ventral nerve cord has **segmental ganglia**.

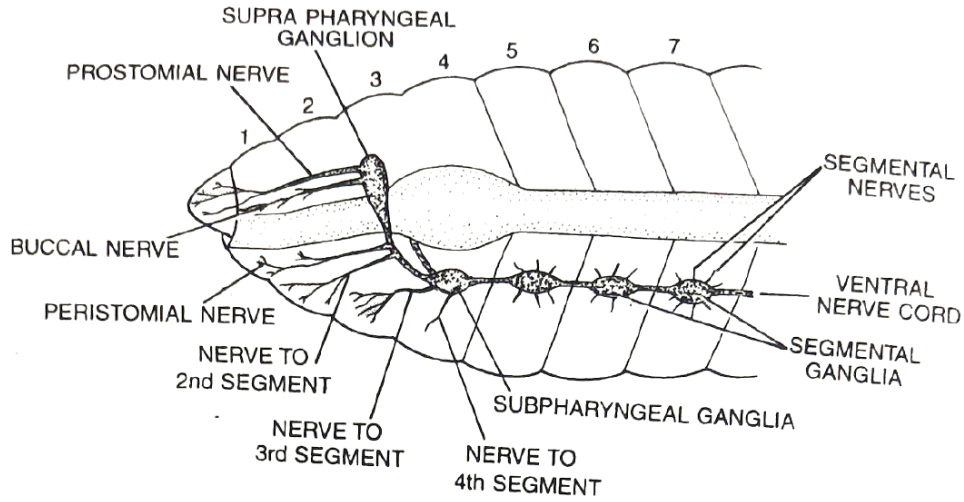

Fig. 7A.17. Nervous system of earthworm in lateral view.

2. **Peripheral nervous system**. The nerves arising from the central nervous system and supplying the various parts of the body constitute the peripheral nervous system. Two pairs of nerves arise from supra-pharyngeal ganglia and supply the prostomium and buccal cavity. Two pairs of nerves arise from the peripharyngeal connectives and innervate the structures present in first (peristomium) and the second segments. Two pairs of nerves arise from the subpharyngeal ganglia and supply branches to organs of third and fourth segments. Three pairs of nerves arise from each segmental ganglion : one pair from the anterior part and two pairs from the posterior part of the ganglion. These nerves innervate the structures present in the respective segments. All the segmental nerves are mixed in nature *i.e.*, containing both sensory (afferent) and motor (efferent) nerve fibres.

3. **Autonomic nervous system**. It consists of an extensive **nerve plexus** situated beneath the epidermis, within the muscles of the body wall and on the alimentary canal. These plexuses are connected with the peripharyngeal connectives.

Receptors or Sense Organs

The organs concerned with the reception of the stimuli are known as receptors or sense organs. In earthworm there are present three types of receptors. (1) **Tactile receptors**. These receptors are distributed in the epidermis more or less throughout the epidermis of the body wall. But they are more numerous on the lateral and ventral surfaces than on dorsal surface. They are sensitive to touch. (2) **Buccal receptors**. They are present in the epithelium of the buccal cavity. These receptors are the organs of *taste* plus *smell* and are, therefore, also referred to as **chemoreceptors**. (3) **Photoreceptors**. They are abundant in the epidermis of the prostomium and peristomium (first segment), while in other segments they are present in lesser numbers. They are not found on the ventral surface. Each photoreceptor is a single celled (**unicellular**) structure which contains a nucleus and a clear lens in the cytoplasm. Lens is also called **phaosome** in earthworm. The cytoplasm has a network of

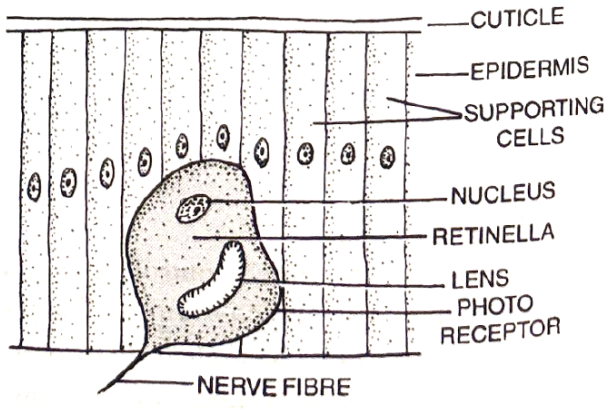

Fig. 7A.18. Photoreceptor of earthworm.

neurofibrils, the **retinella** from which nerve fibres arise. These receptors detect the intesity of light.

Reproductive System

It is a group of organs which are concerned with the production of new individuals to continue the race. Earthworms are **bisexual** or **monoecious** or **hermaphrodite**, *i.e.*, both male and female reproductive organs are present in the same individual. But self-fertilization does not occur as the male and female reproductive organs (testes and ovaries) do not mature at the same time. The testes mature earlier than the ovaries. Such a condition is known as **protandry** and the animal is called **protandrous**. The self-fertilization is also not possible in this animal because of the relative position of the openings of male and female reproductive organs. The cross fertilization takes place after copulation. The fertilization is followed by cocoon formation.

Male Reproductive Organs

They consist of the following organs :

1. **Testis sacs**. The two pairs of *testis sacs* are situated in the tenth and eleventh segments. Each testis sac of the tenth segment encloses a **testis** and a **seminal funnel**. It also communicates with the seminal vesicle present in the eleventh segment. Each tastis sac of the eleventh segment encloses a testis, a **seminal vesicle** and a **spermiducal funnel**, while at the same time it communicates with the seminal vesicle present in the twelfth segment.

2. **Testes**. There are present two pairs of testes. Each testis arises from the anterior wall of each testis sac. Immature spermatozoa produced by the testis first enter the cavity of the testis sac and then they make their way into the seminal vesicle where they undergo further development to become mature sperms.

3. **Semianl vesicles.** There are present two pairs of speminal vesicles. One pair lies in the testis sacs of the eleventh segment but it communicates with the testis sacs of the tenth segment. The other pair of seminal vesicles lies in the twelfth segment but it communicates with the testis sacs of the eleventh segment. They receive the spermatozoa produced by the testes through the testis sac. The spermatozoa undergo further development and maturation in the seminal vesicles where the sperms are ultimately stored.

4. **Spermiducal funnels.** There are two pairs of spermiducal funnels, one pair lying in the testis sacs of the tenth segment and

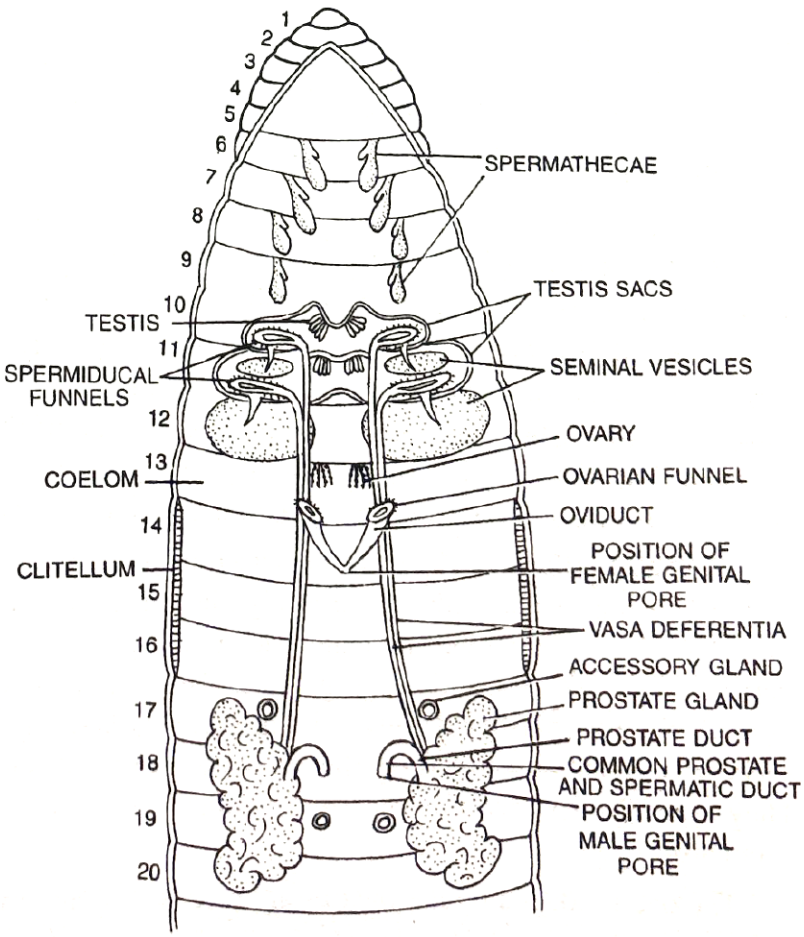

Fig. 7A.19. Reproductive system of Earthworm (testis sacs are cut to show the internal structures of lodged organs).

the other in the testis sac of the eleventh segment. Each spermiducal funnel leads into a fine tube, the vas deferens.

5. **Vasa deferentia**. There are present two pairs of vasa deferentia. Each spermidual funnel leads into a vas deferens. Two vasa deferentia of each side run very close to each other upto the 18th segment. In the 18th segment both the vasa deferentia of each side are joined to the prostate duct from the prostate gland. These three ducts (two vasa deferentia and one prostate duct) of each side are enclosed in a common thick muscular sheath, called the common **prostate** and **spermatic duct**. However, the three tubes are internally distinct and open to the outside separately into male genital pore by three distinct apertures on the ventrolateral side.

6. **Prostate glands**. A pair of large prostate glands is present in earthworm. They are flat and irreglar in outline. These glands are situated on either side of the intestine and extend from the 17th to the 20th segment. They produce a secretion, the prostatic secretion which is transferred to outside on the ventral side near the opening of the vasa deferentia. The secretion perhaps serves as a medium for transfer of sperms.

7. **Accessory glands**. There are two pairs of whitish rounded glandular masses situated internally in 17th and 19th segments. Each accessory gland opens outside ventrolaterally by several ductules on each genital papilla. The secretion of these glands is supposed to help in keeping the two worms close together during copulation.

The spermatoza produced by the testes are received by the testis sacs from where they travel to the seminal vesicles. In the seminal vesicles they undergo further development cum maturation to become ultimately sperms. The sperms are also stored in seminal vesicles for some time. Later on they pass from the seminal vesicles to the testis sacs, from where they find their way to the spermiducal funnels. From the spermiducal funnels the sperms are transferred back through the vasa deferentia and are ultimately passed outside through the male genital pores. During copulation the sperms are passed on to the spermathecae of another earthworm.

Female Reproductive Organs

Female reproductive organs consist of the following structures :

1. **Ovaries**. There is a pair of white minute masses of the ovaries attached to the posterior surface of the septum present between 12th and 13th segments. Ovaries are larger than testes. They produce ova.

2. **Oviducts.** The oviducts are two short tubes each lying immediately behind the respective ovary. The two ovarian tubes run backwards and converge to meet in the body wall and open to outside by a **female genital pore** on mid-ventral side of the 14th segment. The mature ova liberated by each ovary are received by the oviducts and pass ova outside through the female genital pore.

3. **Spermathecae**. There are present four pairs of spermathecae which lie in the sixth, seventh, eighth and ninth segments, but anterior parts of all the spermathecae are attached to the septa between 5/6, 6/7, 7/8 and 8/9 segments. They open to outside through the **spermathecal pores** situated ventro-laterally in the successive grooves separating the above mentioned segments. They store the sperms received from another earthworm during copulation.

The ova produced by the ovaries are received by the oviducts and are finally passed outside into the girdle through a female genital pore. It is the cocoon where the fertilization and development of the embryoes take place.

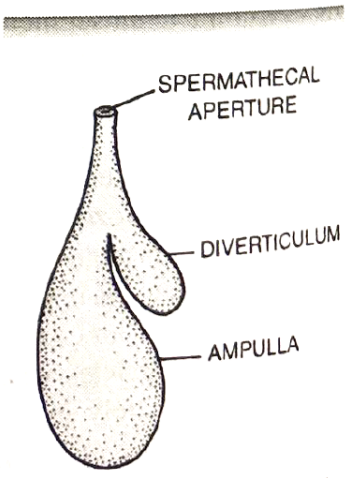

Fig. 7A.20. Spermatheca of earthworm.

Copulation and Cocoon Formation

As stated earlier the earthworms are bisexual or hermaphrodite or monoecious, *viz.*, both male and female sex organs are found in one individual. They are protandrous, *viz.*, male sex organs mature earlier than the female. Thus, self-fertilization is not possible, and cross fertilization occurs, which is accompanied by the copulation. The copulation takes place during night or in the early morning from July to October in rainy season. Two worms attach themselves with their ventral surfaces and become opposed to each other in opposite direction. During copulation **male genital papilla** of one earthworm is inserted into the spermathecal pore of the other earthworm to transfer the sperms and prostatic fluid. After copulation two earthworms separate. Now the glandular cells of the clitellum secrete a fluid that forms a **girdle** around the clitellum. The girdle is filled with mature ova released through female genital pore. The worm wriggles backwards. When the girdle passes over the spermathecal pores it receives the sperms stored in the spermathecae and albuminous secretion of the epidermal gland cells of skin. Ultimately, the worm wriggles out completely and the girdle is, therefore, left free in moist soil. Now this structure is called **cocoon.** Fertilization and development occur inside the cocoon and on an average four baby worms are produced in one cocoon. Other eggs (zygotes) are used as food by the developing embryoes. Development is direct (without larva).

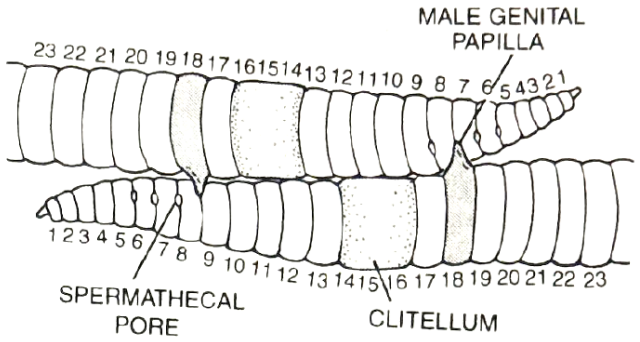

Fig. 7A.21. Copulation in earthworm.

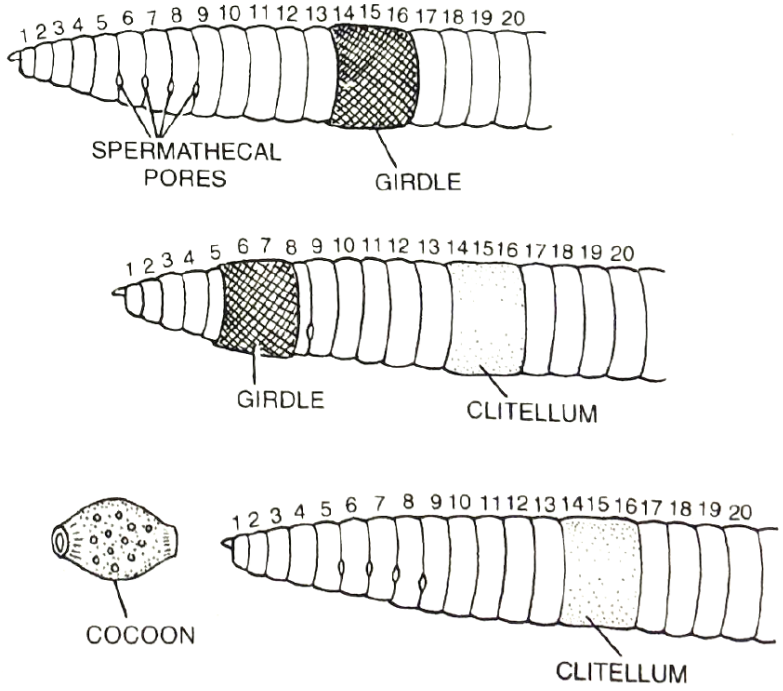

Fig. 7A.22. Cocoon formation in earthworm.

It should be noted that the copulation has not been studied in *P. posthuma*, because it probably takes place deep under the ground.

Interaction with Mankind

Earthworms are known as 'friends of farmers' because they make the soil loose and porous by their burrowing habit. Thus, the soil provides quick aeration and absorption of water, thereby the roots of the plant get penetrated easily with water. Earthworms continuously bring the lower soil on the surface, and deposit it there. Thus, they plough the land, and share the work of the

farmers. The large soil particles are ground up into finer ones by the gizzard (a grinding organ of their alimentary canal). Thus, it provides more surface to the soil for water absorption.

Worm castings of the earthworms are of manurial value. The nitrogenous wastes, and other secretions of this worm also form important plant food. In this way they increase the fertility of the soil. The process of increasing fertility of soil by earthworm is called **vermicomposting**. Earthworms reduce both acidity and alkalinity of the soil and, thus, create optimum conditions for plant growth. Earthworms are also used as food in some countries such as China, Japan, Myanmar (Burma), Australia, etc. They are used as bait for catching the fishes all over the world. Many tribal communities in India use earthworm in the form of medicine to cure bladder stones, jaundice, piles, diarrhoea, etc. Earthworm may cause some harm to man. They may damage young and tender palnts. During rainy season, they cause soil erosion by making burrows to some extent. They spoil the play-grounds by digging burrows in them. Sometimes, their burrows cause the loss of water from the irrigated lands. Some earthworms serve intermediate hosts for some parasites such as tapeworm of chicken and lung nematode of pigs.

The population of earthworms is declining due to excess use of pesticides and chemical fertilizers. Since many animals such as frogs, lizards and birds eat earthworm, hence these animals are also being affected indirectly and resulting in ecological imbalance.

PERIPLANETA (Cockroach)

The cockroaches are one of the most common insects, usually found in the houses. Two kinds of cockroaches are usually found in India, *viz., Periplaneta americana* and *Blatta orientalis*, which can be distinguished as follows :

Differences between Periplaneta americana and Blatta orientalis

Periplaneta americana	*Blatta oreintalis*
1. It is about 5 cm. long and reddish brown in colour.	1. It is about 2-5 cm. long and dark brown in colour.
2. Both male and female have large, well developed wings, covering the entire abdomen.	2. The wings of the male are shorter than the body, while in the female the wings are rudimentary.
3. It is a native of America and has spread to the other parts of the world.	3. It is a native of Asia but has spread to other parts of the world also.

Systematic position

Phylum	—	Arthropoda
Class	—	Insecta
Order	—	Dictyoptera
Family	—	Blattidae
Genus	—	*Periplaneta*
Species	—	*americana*
Common Name	—	Cockroach

Habitat. Cockroaches are found in warm, dark and damp places. They commonly inhabit kitchens, restaurants, store houses, godowns, railway wagons, ships, etc. They are numerous in underground drains.

Habits. They are **nocturnal** insects prefering darkness and become active during night, but remain hidden under some objects and take rest during day time. Cockroaches are **omnivorous** in diet, feeding on almost all kinds of food matter including human food, paper, leather, cloth and